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Abstract

PHYSICS AND ENGINEERING DESIGN OPTIMIZATION OF NUCLEAR POWER PLANT USING GRADIENT METHODS

by

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The problem of designing an optimum nuclear power plant amounts to the minimization of some objective function, e.g. the function defining the unit cost of electricity in terms of the relevant design variables, subject to a number of constraints. These constraints include the design equations governing the relationship between these variables, the restrictions on the magnitude of some variables, etc. This nonlinear problem can be solved by appropriately modified gradient techniques such as the method of steepest descent, the optimum gradient method, the accelerated optimum gradient method and Newton's method. The application of these methods to the above mentioned problem are described using a specific nuclear power plant as model.

Gradient methods generally require an initial design which must satisfy all the constraints; this can be a laborious problem. Procedures are described which will automatically produce such a design from an approximate set of values for the design variables.

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Two major problems which beset gradient procedures are: 1) errors propagated by the method, and 2) convergence. The first is tied in ultimately with the inversion of matrices of large order. This problem is discussed and illustrated with results obtained for a case problem. Techniques whereby the convergence may be accelerated are described and results obtained by their use given.

The problem of trying to establish whether there are several relative minima in the field of interest to designers are mentioned and a technique described which constrains the gradient methods such that they converge to a saddle point, if such a point exists, from which all the surrounding relative minima may be found.

A simplified block diagram is included showing the assembly of all the above procedures in a form suitable for coding a digital computor program.

The procedures described have been applied to a nuclear power plant involving a total of 63 parameters and 48 constraints and programmed for the IBM 7094 computor. The complete power plant design, including engineering and neutron physics, was considered in order that there may be free interplay between parameters in different sections of the plant, the purpose being to attempt to design an over-all optimum plant rather than an assembly of optimum sections as is often the case. Available results illustrating convergence rates, round-off error in the resulting 48 x 48 matrix, and times for the different operations are given.